

Letters to the Editor.

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Theories of Atomic Structure.

IN a letter to NATURE (March 11, p. 41) S. C. Bradford stated: "The great objection to Langmuir's theory of atomic structure is the difficulty of accepting his hypothesis of stationary electrons." The cases cited are all discussed in G. N. Lewis's paper, "The Atom and the Molecule" (Journ. Amer. Chem. Soc., xxxviii., p. 762, April, 1916), so it is scarcely fair to Lewis to refer to the theory as "Langmuir's theory."

Although Lewis frankly implied that the electrons in atoms are stationary, his theory of valency did not depend upon such an assumption. The chemical data give information in regard to the geometry of atoms, and, in particular, tell us of the kinds of symmetry which they possess. From the chemical point of view it is at present a matter of comparative indifference what the motions of the electrons may be so long as they conform to the required conditions of symmetry. For this reason I was careful to state in my first paper (Journ. Franklin Inst., clxxxvii., p. 359, March, 1919, and Journ. Amer. Chem. Soc., xli., p. 932, 1919) that "the electrons in atoms are either stationary or rotate, revolve, or oscillate about definite positions in the atom." It was, perhaps, not sufficiently emphasised that the positions of the electrons shown in the diagrams may be regarded as the centres of their orbits.

It is sometimes thought that the success of Bohr's theory furnishes reason for believing that all the electrons in atoms are rotating in coplanar orbits about the nucleus. There is little justification for this opinion. The remarkable results yielded by Bohr's theory, particularly in the hands of Sommerfeld, for the case of the hydrogen atom and the helium ion seem to prove beyond question that in an atom containing only one electron this electron actually revolves in a circular or elliptical orbit about the nucleus. Although Bohr's theory has had some applications to other atoms, these are, for the most part, of a very general nature, such as those which relate to the combination principle. The theory does not give a satisfactory model even for such simple structures as the hydrogen molecule or helium atom (see, for example, Sommerfeld's recent book, "Atombau und Spectral-linien").

From the chemical point of view Bohr's theory is wholly unsatisfactory when applied to atoms containing more than one electron. Thus, according to Bohr's calculations (*Phil. Mag.*, xxvi., p. 492, 1913), a lithium nucleus surrounded by three equidistant electrons should have less potential energy (and, therefore, greater stability) than one in which one electron is further from the nucleus than the other two. Bohr's theory thus gives no reason for the contrast between the properties of lithium and helium.

The two theories are not mutually incompatible if we consider that, in general, the electrons do not revolve about the nucleus, but about definite positions symmetrically distributed in three dimensions with respect to the nucleus. It is interesting to note that Born and Landé (*Verh. deut. physik. Ges.*, xx., pp. 210, 230, 1918), starting out from Bohr's theory and without knowledge of Lewis's work, were led to the theory of the cubical atom by a study of the compressibilities of the alkali halides. They conclude that the electron orbits do not lie in a plane, but are arranged in space with cubic symmetry. Sommerfeld

in his book suggests that this conception may help to solve some of the outstanding difficulties, and evidently does not consider it inconsistent with Bohr's theory.

In the case of atoms which do not share electrons with other atoms, it is logical to assume that each electron in the outer shell has its own orbit. Thus the atoms Ne, Na⁺, Mg⁺⁺, F⁻, and the S atom in SF₆ should have cubic symmetry, the eight outer electrons revolving about positions located at the corners of a cube. But where a pair of electrons is held in common between two atoms, the chemical evidence indicates that the pair acts as a unit. When an atom shares four pairs of electrons with its neighbours, it thus has tetrahedral rather than cubic symmetry. So far as the chemical evidence is concerned, it would be satisfactory to adopt Bohr's model for the hydrogen molecule to represent the pair of electrons which constitutes the chemical bond. We may thus picture the chemical bond as a pair of electrons revolving in a single orbit about the line connecting the centres of the two atoms.

Bohr in his 1913 paper (*Phil. Mag.*, xxvi., p. 874) states: "The configuration suggested by the theory for a molecule of CH₄ is of the ordinary tetrahedron type; the carbon nucleus surrounded by a very small ring of two electrons being situated in the centre, and a hydrogen nucleus in every corner. The chemical bonds are represented by four rings of two electrons each rotating round the lines connecting the centre and the corners." This structure is quite consistent with the octet theory. Bohr did not, in general, identify a pair of electrons with a valency bond.

When we consider, however, that Bohr's theory in its present form does not furnish an explanation of the stability of the pair of electrons in the helium atom and in the bond between atoms, it is evident that the model described above can scarcely be regarded as satisfactory. It seems as though some factor of vital importance is still missing in Bohr's theory. The chemical data suggest that the ultimate theory will be extremely simple, but perhaps more radical than anything yet proposed.

I am in full agreement with the views put forward by Dr. H. S. Allen in NATURE for March 18, p. 71.

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Decimal Coinage.

IN NATURE of April 1, p. 145, reference is made to the unfavourable report of the Royal Commission appointed to inquire into the above subject. It would appear from a close study of the findings of the Commission that the failure to solve this century-old problem was due more to differences between the advocates than to opposition to the principle.

Although fifteen of the twenty Commissioners would prefer to decimalise the existing £ sterling rather than to create a new monetary unit equal to 100 halfpence, it is significant that only four of them could agree that the advantages to be secured by the decimalisation of the £ would outweigh the inconvenience arising from the change. This is tantamount to an admission that the method of dealing with the penny difficulty as proposed in Lord Southwark's Bill (£—mil) was unduly complicated. (No exact equivalent of the penny was provided, the choice of a 4-mil and 5-mil piece being alternatively offered.)

Retaining the £ as the unit, there are three possible values for the penny, viz.:

4 mils = the present penny less 4 per cent.

5 mils = the present penny plus 20 per cent.

4½ mils = the present penny exactly.

The claims of these denominations may be summed up as follows:

The 4-mil Penny.—As the denomination 4 represents neither a decimal multiple of 1 nor a binary division of 10, a 4-mil coin could have no permanent place in any decimal coinage system. As a transitional value it would also be unattractive, because it would still further reduce the purchasing power of the penny at a time when an increase is needed, and its temporary adoption would involve two adjustments of existing pennyworths, thus doubling, instead of removing, the difficulty. For these and other reasons a 4-mil penny may be safely dismissed from our consideration.

The 5-mil Penny.—There are at least four good reasons in its favour, viz.:

(1) In a decimal coinage system prices are normally arranged in steps of 5, e.g. 5, 10, 15, 20, 25, etc., and the value of 5 mils would fall conveniently between that of the unduly high 5 American cents and the unnecessarily low 5 centimes of the Latin Union.

(2) The reduction of the present high prices would be hastened by the provision of a penny of this value. The price of a pre-war pennyworth, now sold at three-halfpence, could obviously be reduced to 5 mils long before it could be restored, if ever, to the original penny.

(3) The prevailing shortage of copper coins would be relieved by thus increasing the token values of all the penny and halfpenny coins now in circulation. Two copper coins are now employed in countless transactions where formerly one sufficed, and this fact alone, quite apart from decimalisation, demands a penny of higher value.

(4) The simple relationship of 10 pence to the shilling would be readily grasped by the uneducated, and the deservedly popular single-coin payments would be restored. Retail shopkeepers could, if so desired, continue to keep their accounts in £ s. d. instead of £ f. m., the 2½, 5, 10, and 25 mil coins being in that case entered as ½, 1, 2, and 5 pence, all the higher value coins retaining their present descriptions as 1, 2, 5, and 10 shillings respectively.

Note.—The majority Commissioners apparently feared that 5 mils would always be charged in place of the present penny. If they had said in place of the present three-halfpence, they would have been just as near the truth, which possibly lies between these two views. Probably everyone would now be very glad to pay 5 mils for a pre-war pennyworth of anything—the trouble is we are charged three-halfpence or more. When introducing this year's Budget the Chancellor of the Exchequer (referring to his proposal to raise the receipt duties from 1d. to 2d.) said: "This change is no more than reflecting the altered value of the penny."

The 4½-mil Penny.—If there are insuperable difficulties in the way of raising the values of the existing penny and halfpenny coins to make them serve as tokens for 5 mils and 2½ mils respectively, they could remain in circulation at their present values side by side with new 5-mil nickel coins, in which event their values in mils could be expressed as 4-2 and 2-1 respectively, the latter figure representing twelfths of a mil. (These expressions would be no worse than our present use of 4/2 to represent four shillings and two-twelfths.)

The present penny could thus be preserved indefinitely for the continued exact payment of all statutory pennyworths, but the competition of the smaller, lighter, and cleaner 5-mil nickel coin, representing a value in closer harmony with present-day needs, would rapidly drive the bronze penny out of popular favour for the countless single-coin payments of daily life. In concluding, that this method might involve the dual circulation of pence and mils "for seventy-five years or more," the majority Commissioners have unwarrantably assumed that no steps

would be taken by the established "penny" interests, such as insurance and tramway authorities, etc., to bring themselves into line with the new mil system, whereas many of these interests are already agitating for legislative authority to abandon the penny basis, which has proved inadequate to cover operating costs. Many of the old fixed penny charges, such as the penny stamp, penny-a-mile, etc., have already disappeared, and the retention of the coin itself is no longer a matter of vital importance.

The £ sterling could thus be decimalised either without altering the penny or by raising its value to 5 mils (either instantaneously or gradually), and so securing substantial benefits over and above those normally arising from decimalisation.

Having very truly said: "It is necessary to distinguish between the coins in circulation and the reckoning of money of account," and having properly referred to the human habit of halving quantities, the Commissioners failed to realise that it is quite practicable to combine the advantages of decimal accounts and binary coins. Such a composite scheme would provide decimal multiples and binary divisions thus:

Coins	In accounts	Equivalent
Gold or Note:	£ f. m.	£ s. d.
Pound	1 0 00	1 0 0
Half-pound	5 00	10 0
Quarter-pound (crown)	2 50	5 0
Silver:		
Florin	1 00	2 0
Half-florin (shilling)	50	1 0
Quarter-florin	25	6
Nickel:		
Dime (10-mil piece)	10	2'4
Bronze:		
Half-dime (penny)	5	1'2
Quarter-dime (halfpenny)	2½	0'6
Mil	1	0'24

The above proposal achieves the complete decimalisation of the £ by means of a smaller number of coins and in a simpler manner than by the method described in Lord Southwark's Bill. No decimal point would be needed, the number of figures would be reduced, and no new coins would be immediately required.

HARRY ALLCOCK.

Trafford Park, Manchester, April 21.

International Council for Fishery Investigations.

As the writer of the article on the above subject in NATURE of March 18, I should be disposed to allow Prof. McIntosh's letter in the issue of April 8 based on it to pass without comment if that letter had not been quoted extensively elsewhere. I merely remark that the professor's claim to maintain the same position as he took up in his published criticisms in 1902 and 1903 is fully substantiated. I see no reference in my article to the Moray Firth, which, indeed, had nothing to do with the International Council, and which I must leave Prof. McIntosh to settle with his fishery colleagues in Scotland. His criticism of the representatives of France is out of place, in that representatives of all countries are appointed by their Governments.

Prof. McIntosh confuses the programme adopted with the general discussion which took place first. Commodore Drechsel and others spoke of "the closure of the greater part of the North Sea as the most gigantic scientific experiment ever made [will